FORMALDEHYDE

Identified as a toxic air contaminant under California's air toxics program (AB 1807) in 1992.

CAS Registry Number: 50-00-0 HCHO

Molecular Formula: CH_2O

Formaldehyde is a colorless gas at room temperature and the liquid is clear or water-white. The odor is irritating and pungent. Formaldehyde is very soluble in water and up to 55 percent soluble in ether, acetone, benzene, and alcohol. It is very reactive, combines with many substances, and polymerizes easily (Merck, 1989). It reacts violently with perchloric acid, aniline, performic acid, nitromethane magnesium carbonate, and hydrogen peroxide. Aqueous formaldehyde is corrosive to carbon steel but is not corrosive in the vapor phase. It is not sold commercially because of its tendency to polymerize, but is sold as aqueous solutions (formalin) containing 37 to 50 percent formaldehyde (Sax, 1989; HSDB, 1995).

Physical Properties of Formaldehyde

Synonyms: methanal; formic aldehyde; oxomethane; oxymethylene; methylene oxide; methyl aldehyde; formalin; formic aldehyde; formal; morbicid

Molecular Weight:	30.03
Boiling Point:	-19.5 ºC
Melting Point:	-92.0 ºC
Vapor Pressure:	3284 mm Hg at 20 ºC
Vapor Density:	1.03 for aq. soln.; 1.08 for gas
Density/Specific Gravity:	1.067 (air = 1)
Log Octanol/Water Partition Coefficient:	0.35
Conversion Factor:	1 ppm = 1.23 mg/m^3

(HSDB, 1995; Merck, 1989; Sax, 1989; U.S. EPA, 1994a)

SOURCES AND EMISSIONS

A. Sources

Formaldehyde is both directly emitted into the atmosphere and formed in the atmosphere as a result of photochemical oxidation of reactive organic gases in polluted atmospheres containing ozone and nitrogen oxides. Photochemical oxidation is the largest source (could be as high as 88 percent) of formaldehyde concentrations in California ambient air. A primary source of formaldehyde is vehicular exhaust (ARB, 1992d; U.S. EPA, 1993b). Formaldehyde is a product

of incomplete combustion. About 9 percent of direct formaldehyde emissions are estimated to come from the combustion of fossil fuels from mobile sources (Lawson et al., 1990).

Catalytic cracking, coking operations, and fuel combustion are major sources of formaldehyde from refineries. Stone, clay, and glass production use fuel combustion sources such as boilers, furnaces, and engines in the manufacturing processes which generate formaldehyde. Formaldehyde is used in urea-formaldehyde and phenol formaldehyde resins, copper plating solutions, and incinerators. Formaldehyde-based resins are used in pressed wood, cotton permanent press, grocery bags, and waxed paper. Detergents, cosmetics, and other domestic chemicals contain formaldehyde as an antimicrobial agent (shampoos, bubble baths, and hair conditioners) (ARB, 1992). Formaldehyde is also used in fumigants, soil disinfectants, embalming fluid, and in leather tanning (ARB, 1995). Formalin is used as a disinfectant ionizing solvent in dialysis and as a tissue fixative (Howard, 1990).

Formaldehyde is registered as an antimicrobial. It is used for disinfecting animal premises, in chicken and other poultry handling facilities, for cleaning and sterilizing poultry cages, and as an egg dip. Formaldehyde is registered as a bactericide and used for disinfecting oil drilling muds, secondary oil recovery water systems, and ore processing water systems. Formaldehyde is also registered as antimicrobial, bactericide and fungicide for control of bacteria and fungi on critical and semi-critical hospital equipment, floors, walls, and other hospital areas (DPR 1996).

The licensing and regulation of pesticides for sale and use in California are the responsibility of the Department of Pesticide Regulation (DPR). Information presented in this fact sheet regarding the permitted pesticidal uses of formaldehyde has been collected from pesticide labels registered for use in California and from DPR's pesticide databases. This information reflects pesticide use and permitted uses in California as of October 15, 1996. For further information regarding the pesticidal uses of this compound, please contact the Pesticide Registration Branch of DPR (DPR, 1996).

The primary stationary sources that have reported emissions of formaldehyde in California are crude petroleum and natural gas extraction, manufacturers of miscellaneous nonmetallic mineral products, and gas production and distribution services (ARB, 1997b).

B. Emissions

The total emissions of formaldehyde from stationary sources in California are estimated to be at least 1.8 million pounds per year, based on data reported under the Air Toxics "Hot Spots" Program (AB 2588) (ARB, 1997b). In 1994, the Air Resources Board (ARB) also estimated that approximately 13 million pounds per year were emitted from on-road motor vehicles (ARB, 1995f). The ARB also estimates that emissions from other mobile sources such as off-road vehicles, boats, ships, and trains, contributes an additional 6.8 million pounds per year of formaldehyde into California's air each year (ARB, 1995f).

The ARB has adopted the Low Emission Vehicles/Clean Fuels regulations in 1990 which

is expected to reduce formaldehyde emissions from cars and light-duty trucks (ARB, 1990i).

C. Natural Occurrence

Formaldehyde occurs in forest fires, animal wastes, microbial products of biological systems, and plant volatiles. It can also be formed in seawater by photochemical processes (HSDB, 1995).

AMBIENT CONCENTRATIONS

Formaldehyde is routinely monitored by the statewide ARB toxics monitoring network. The network's mean concentration of formaldehyde from January 1996 through December 1996 is estimated to be 4.15 micrograms per cubic meter ($\mu g/m^3$) or 3.37 parts per billion (ppb) (ARB, 1997c). When formaldehyde was formally identified as a toxic air contaminant the ARB estimated a population-weighted annual concentration of 5.4 $\mu g/m^3$ or 4.4 ppb (ARB, 1992d).

The United States Environmental Protection Agency (U.S. EPA) has also reported concentrations of formaldehyde from 14 study areas during 1989. Overall range of concentrations from these areas were from 0.53 to 11.0 $\mu g/m^3$ or 0.43 to 8.94 ppb with an overall median concentration of 2.6 $\mu g/m^3$ or 2.1 ppb (U.S. EPA, 1993a).

INDOOR SOURCES AND CONCENTRATIONS

The results of California surveys of randomly selected residences indicate that formaldehyde concentrations inside California residences can range from less than 10 ppb (12.3 $\mu g/m^3$) to almost 500 ppb (615 $\mu g/m^3$). Mean concentrations were 24 ppb for office and public buildings, 50 ppb for conventional homes, and 72 ppb for mobile homes. While it appears that formaldehyde off-gases from pressed wood products (particle board, plywood, and fiberboard) over time, indoor levels are expected to remain higher than outdoor levels due to new materials brought into the home as a consequence of remodeling or purchasing new furnishings. Other indoor combustion sources such as wood and gas stoves, kerosene heaters, and cigarettes contribute intermittently to indoor formaldehyde levels (ARB, 1992d).

In general, indoor environments consistently have higher concentrations than outdoor environments, because many building materials, consumer products, and fabrics emit formaldehyde (ARB, 1992d).

In-vehicle studies have found formaldehyde concentrations to be similar to concentrations measured outdoors. A southern California study measured an average formaldehyde concentration of 15.3 $\mu g/m^3$ (12.5 ppb) and a maximum concentration of 35.3 $\mu g/m^3$ (28.8 ppb) during the summer of 1987 and winter of 1988 (Shikiya et al., 1989). Another study in Boston, Massachusetts, measured a mean formaldehyde concentration of 5.1 $\mu g/m^3$ (4.2 ppb) and a maximum concentration of 19.7 $\mu g/m^3$ (16.1 ppb) (Chan et al., 1991b).

ATMOSPHERIC PERSISTENCE

Photolysis of formaldehyde is calculated to dominate over gas-phase reaction with the hydroxyl radical as a tropospheric removal process, with a photolysis lifetime for formaldehyde of about 4 hours. Formaldehyde is also formed in the atmosphere from the photooxidations of most other organic compounds, and hence it is being removed and formed at the same time (Atkinson, 1995). Rain or fog can shorten the atmospheric lifetime of formaldehyde (ARB, 1992d).

AB 2588 RISK ASSESSMENT INFORMATION

The Office of Environmental Health Hazard Assessment reviews risk assessments submitted under the Air Toxics "Hot Spots" Program (AB 2588). Of the risk assessments reviewed as of April 1996, formaldehyde was the major contributor to the overall cancer risk in 39 of the approximately 550 risk assessments reporting a total cancer risk equal to or greater than 1 in 1 million and contributed to the total cancer risk in 297 of these risk assessments. Formaldehyde also was the major contributor to the overall cancer risk in 3 of the approximately 130 risk assessments reporting a total cancer risk equal to or greater than 10 in 1 million, and contributed to the total cancer risk in 82 of these risk assessments (OEHHA, 1996a).

For non-cancer health effects, formaldehyde contributed to the total hazard index in 49 of the approximately 89 risk assessments reporting a total chronic hazard index greater than 1, and presented an individual hazard index greater than 1 in 7 of these risk assessments. Formaldehyde also contributed to the total hazard index in 61 of the approximately 107 risk assessments reporting a total acute hazard index greater than 1, and presented an individual hazard index greater than 1 in 4 of these risk assessments (OEHHA, 1996b).

HEALTH EFFECTS

The most probable route of human exposure to formaldehyde is inhalation.

Non-Cancer: Vapors are highly irritating to the eye and respiratory track. Acute effects include nausea, headaches, and difficulty breathing. Formaldehyde can also induce or exacerbate asthma. Chronic exposure is associated with respiratory symptoms and eye, nose, and throat irritation. Repeated exposure of skin to the liquid causes irritation and allergic dermatitis (U.S. EPA, 1994a).

An acute non-cancer Reference Exposure Level (REL) of 3.7×10^2 $\mu g/m^3$ and a chronic non-cancer REL of 3.6 $\mu g/m^3$ are listed for formaldehyde in the California Air Pollution Control Officers Association Air Toxics "Hot Spots" Program, Revised 1992 Risk Assessment Guidelines. The toxicological endpoint considered for chronic toxicity is irritation of the respiratory system (CAPCOA, 1993). The U.S. EPA has not established a Reference Concentration (RfC) for formaldehyde but the oral Reference Dose (RfD) is 0.2 milligrams per kilogram per day based on a decrease in bodyweight gain and effects on the stomach in rats.

The U.S. EPA estimates that consumption of this dose or less, over a lifetime would not result in the occurrence of chronic, non-cancer effects (U.S. EPA, 1994a).

An increased incidence of menstrual disorders and pregnancy problems were observed in women workers using urea-formaldehyde resins. However, possible confounding factors were not evaluated in this study. A study of hospital equipment sterilization workers did not report an association between formaldehyde exposure and spontaneous abortions (U.S. EPA, 1994a). Exposure of experimental animals to formaldehyde does not appear to result in teratogenic or reproductive effects of significance (ARB, 1992d).

Cancer: According to the U.S. EPA, limited human studies have reported an association between formaldehyde exposure and lung and nasopharyngeal cancer (U.S. EPA, 1994a). Formaldehyde is carcinogenic in rodents, producing squamous cell carcinomas in the nasal passages of male and female rats and male mice (ARB, 1992d).

The U.S. EPA has classified formaldehyde in Group B1: Probable human carcinogen, with an inhalation unit risk of 1.3×10^{-5} (microgram per cubic meter)$^{-1}$. The U.S. EPA estimates that if an individual were to breathe air containing formaldehyde at 0.08 $\mu g/m^3$, over a lifetime, that person would theoretically have no more than a 1 in 1 million increased chance of developing cancer (U.S. EPA, 1994a). The International Agency for Research on Cancer has classified formaldehyde in Group 2A: Probable human carcinogen based on limited evidence in humans and adequate evidence in animals (IARC, 1987a).

The State of California has determined under Proposition 65 and AB 1807 that formaldehyde is a carcinogen (CCR, 1996; ARB, 1992d). The inhalation potency factor being used as a basis for regulatory action in California is 6×10^{-6} (microgram per cubic meter)$^{-1}$ (OEHHA, 1994). In other words, the potential excess cancer risk for a person exposed over a lifetime to 1 $\mu g/m^3$ of formaldehyde is estimated to be no greater than 6 in 1million (OEHHA, 1994).